IMPACT CRATERS IN THE ANTARCTIC ICE SHEET: ACCUMULATION RATE, CRATER MORPHOLOGY AND EVOLUTION, RADAR SIGNATURE. N. E. Demidov[1,2] and D.G. Shmelev [3 1] Vernadsky Institute of Geochemistry and Analytical Chemistry, RAN, Kosygin Str.,19, Moscow 119991 Russia, nikdemidov@mail.ru, [2] Institute of Physicochemical and Biological Problems of Soil Science, RAN, Pushchino, Moscow region 142290 Russia, [3] Lomonosov Moscow State University, Geography facylty, Moscow, 119243.

Introduction: Impact craters are the most fundamental geomorphological process in the inner parts of Solar System. Their role is obvious in the formation of Mars, the Moon and Mercury which reflect the history of a heavy bombardment period, 4.6 – 3.3 Ga ago [1]. Photogeologic analysis of the Moon surface combined with age dating of samples from Apollo and Luna missions has provided age and size dependent functions of lunar impact rate [2, 3]. Several approaches were proposed to estimate cratering rate on Earth based on recalculation of lunar crater production function and geological dating of nearly 180 terrestrial astroblems (Ivanov, 2008a). In our study we use this data to test possibility of presence of specific type impact structures in the Antarctic Ice Sheet, the oldest and largest terrestrial ice sheet.

Accumulation rate: Theoretically, a number of craters at given region is a function of surface area **S**, accumulation time **T** and crater diameter **D**. The surface of the Antarctic is 12 400 000 km^2 (2.4 % of Earth). The age of ice in the Antarctic ice sheet varies from 0 at the surface to 960 k.a. in deep basal ice cores from Dome Concordia [5]. According to basal ice age model [6] the Antarctic is divided in to the Western Antarctic, with a basal ice age <200 k.a. and central part of the Antarctic ice sheet with a basal ice age >200 k.a.. In our study we did not take into account regional variations in age and calculations were performed for three sets of **T**: 10 k.a. (lower limit), 100 k.a. (median) and 1 000 k.a. (upper limit). To predict number of craters in Antarctica we used Earth crater production functions from Melosh [7] (equation 1) :

$$K=1/(1400\cdot D^2) \qquad (1)$$

where D – crater diameter (km), K – impact rate (number of craters with diameter > or = D per year generated on all Earth), and validated them by Neukum lunar production function adapted by Ivanov to Earth [8]. Results presented in figure 1 and 2 show good agreement and possibility of several 1-3 diameter craters presence in Antarctica.

Crater morphology and evolution: Absence of discovered icy astroblems on Earth makes it impossible to directly investigate icy astroblems as done for craters in rock. Icy craters exist on Martian polar caps as well as on icy satellites of Jupiter and Saturn, but they were formed under different conditions from Earth, namely ice composition and temperature, gravity

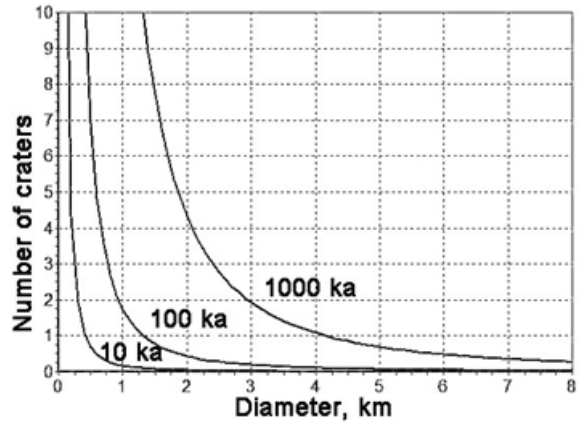

Fig. 1 Cumulative number of craters in Antarctica accumulated per 10, 100 and 1000 ka. Estimation made by equation (1)

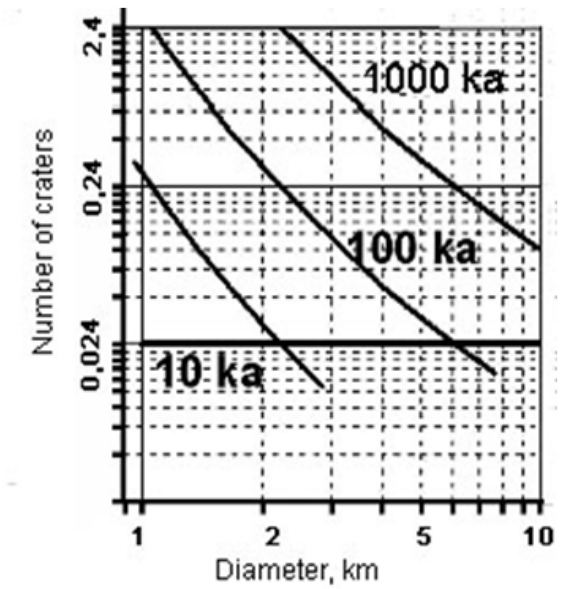

Fig. 2 Cumulative number of craters in Antarctica accumulated per 10, 100 and 1000 ka. Adapted from all Earth surface impact craters accumulation rate calculations - fig. 8 in [8]

and impact velocity. Recently developed models predict specific features of icy craters for wide range of conditions in the Solar System [9]. In our model we assume that basic morphology of 3 km diameter icy crater is characterized by the same structure as craters in rocks plus layer of melt water freezing in to ice lining crater floor (fig. 3, age 0). Crater evolution in time is combination of several factors. The Central Antarctic snow and blizzard mean annual accumulation rate of < 5 cm [10] can be taken as lower limit of surface coverage rate resulting in 20 k.a. life time of 1 km deep crater. Snow blizzards and fluidity of ice, especially in case of absence of evident crater swell, may shorten crater life time to approximately several k.a.. After the end of obliteration stage (fig. 3, age <20 k.a.) buried impact structure continue its evolution at depth. It moves in horizontal direction with glacier from the accumulation area to the ocean as well as continuing to be buried by snow, as a result of which astroblem moves in the direction down from the surface. Dipping of impact structure also means the structure is flattering under pressure (fig. 3, age 100 k.a.).

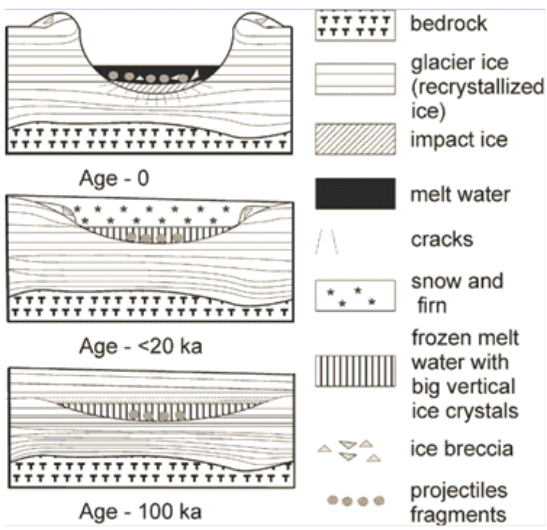

Fig. 3 Icy crater primordial morphology, structure and evolution.

Geophysical identification: The Antarctic ice sheet is characterized by monotonous flat relief which is disturbed only by fields of megadunes or by extensive smooth variations in underneath bedrock relief. The obvious task for the first step in search for Antarctic astroblems is the identification of distinctive subcircular relief depressions with diameter up to 3 km using altimetry data. However, our calculations of accumulation rate of impact structures taken together with estimations of its life time predict low possibility of crater presence in modern glacier relief. The presence of buried in ice and altered astroblems is more probable. The Antarctic ice sheet may contain a number of astroblems from 1-3 km craters (fig. 1 - 2). Their search may be based on radar data. Signature of astroblem in radar data is subcircular n·km scale structure with complex of anomalous layers (fig. 3, age 100 k.a.): (1) layer of frozen melt water with big vertical ice crystals, (2) layer with scattered projectiles fragments, (3) unconformity of bottom astroblem boundary with primordial glacier layers.

Summary: As we are only in the beginning of solving this complicated multidisciplinary question, here we present no definite answer but mainly the methodology of Antarctic ice craters survey. The Antarctic ice sheet may contain a number of astroblems buried in ice and modified from 0 - 3 km craters. Their signatures in radar data may be predicted by modeling of icy craters formation and evolution. Drilling and sampling of icy astroblem is essential to understanding possibility of preservation of asteroid and comet material in ice.

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